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A DECISION SUPPORT APPROACH TO ADDRESS NEW SUGARCANE QUALITY-BASED PAYMENT SYSTEMS

By

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Abstract

IN SUGAR industries where growers and millers are independent economic entities, payment systems aim at sharing the annual sugar industry revenue. They have been designed to create incentives to improve milling performance, cane yields and quality. Like most revenue sharing agreements, they tend to be a contentious issue between growers and millers. In some industries, while modifying payment systems can be the key to increasing industry profitability, mistrust between growers and millers can hamper such improvements. The situation is now exacerbated by the development of sugarcane co-products, such as ethanol, electricity or by-products for niche markets, which can generate higher benefits than sugar, thus calling for a rethink of payment systems. This paper presents a decision support approach which aims to assess new cane payment systems while increasing revenue sharing transparency. It is based on a simulation tool called Pempa, which helps to assess the impact of new cane payment systems on growers' revenue and on revenue sharing between stakeholders. Experiments have been carried out for 3200 growers supplying two mills on Réunion Island, to test the impact of implementing a new payment system based on a relative formula. Results showed that the simulation approach could facilitate understanding and implementation of a new payment formula, especially for multiple-purpose sugarcane.

Introduction

In sugar industries where growers and millers are independent economic entities, payment systems aim at sharing the annual sugar industry revenue resulting from the sales of sugar and all sugarcane by-products such as molasses and bagasse. They have been designed to create incentives to improve milling performance, cane quality and cane yields.

A review of sugarcane payment systems in the main sugarcane producing countries (LMC, 2002) showed that payment systems vary between, and sometimes within, countries depending on four main elements:

- Sugar and co-products price.
- Revenue sharing agreement between growers and millers. Revenue resulting from the sale of sugar is redistributed between growers and millers on a fixed basis (x% for the growers, (100-x) % for the factory) or on a variable basis (the price is defined for a standard level of quality and a fixed extraction capacity).
- A global payment formula. In all sugarcane industries, the tonnage delivered is used as a basis for payment. Tonnage can be combined with the mill average quality, a group average quality (especially for small-scale farmers) or an individual quality analysis.

- The definition of 'sugarcane quality' and the parameters used for quality payment. The indicator used to define sugarcane 'quality' differs between countries. It can be the sucrose content, an estimation of the recoverable sugar present in each tonne of cane or an estimation of the value of a tonne of cane in terms of marketable product. It can depend on elementary indicators, such as sucrose and fibre content, mill extracting capacities, materials and methods used for quality measurements, etc.

In practice, it is hard to design a 'perfect' payment system and guarantee that equity is always maintained while ensuring that incentives, for both growers and millers, are not distorted (Todd and Forber, 2005).

In most countries, payment systems are based on complex and sophisticated formulae. They have been built through successive historical negotiations, readjusted according to mill performance or growers' practice improvements and tend to be a contentious issue between growers and millers (Lejars, 2008).

Thus, in some industries, while modifying payment systems can be the key to increasing industry profitability (Kroes and Fadden, 2004: Higgins and Muchow, 2003; Le Gal *et al.*, 2008; Lejars *et al.,* 2008), mistrust between growers and millers and the fact that each of these stakeholders may not be able to clearly assess the impact of modifications in their own revenue can hamper such improvements.

The situation is now exacerbated by the development of sugarcane co-products, such as renewable energy from ethanol or electricity (Keating *et al*, 2002; Sutherland, 2002), fibre-based commodities (paper, packaging, etc.) or other niche products like furfural alcohol or lactic acid. Most payment systems currently aim at promoting the production of cane for sugar extraction. They encourage high sucrose content while penalising fibre rate, despite the fact that fibre can be used to produce by-products that have a higher value than sugar.

In some countries, part of the revenue from by-product sales can be allocated to growers depending on the tonnage of sugarcane delivered. However, by-product payments are independent of the quality parameters. Payment systems are generally adapted to a sector in which the main outlet is sugar. The development of multiple-purpose sugarcane, whether or not earmarked for sugar production, calls for a rethink of payment systems (Wynne, 2007; Higgins *et al.,*, 2007).

More generally for agro-industries, very few support systems have been developed to design payment systems. Some studies have been undertaken to design optimal quality price schemes (Zago, 2006), especially in wine industries (Touzard *et al*, 2001). Bouche and Attonaty (1999) conducted experiments on milk price elaboration to define quality standards.

As 'milk quality' has different meanings for different stakeholders, their objective was to build a typology to differentiate and define the different representations of quality. However, the implementation of new payment systems remains difficult and sometimes impossible when stakeholders are not involved in the decision process from the beginning and when they are not able to assess the impact of new payment systems on their own income.

This paper presents a decision support approach which aims to assess new cane payment systems while increasing revenue sharing transparency and quality incentives impacts on revenue. A software, called Pempa (Auzoux *et al.,* 2008), has been developed in order to facilitate assessment of the impact of new cane payment systems on growers' revenue and on revenue sharing between stakeholders.

Firstly, we focus on the method and the tool used to support payment system implementation. Then, we present an application tested in Réunion to achieve a more transparent alternative cane payment system based on a relative formula. Finally, we show how this method could be applied to alternative payment systems for multiple-purpose sugarcane in the near future.

The decision support approach

Objectives

The decision support approach aims to assess the impact of new cane payment systems on growers' revenue and on revenue sharing between stakeholders. It is based on software called Pempa, which has been designed specifically for sugarcane industries.

The new payment formulae are developed by an expert or in partnership with stakeholders. Once stakeholders agree on the definition of sugarcane 'quality', the simulation tool assesses the impacts of new quality-based payment formulae on individual revenue. The purposes are to: (i) facilitate comprehension of the incentive effects of quality payment formulae, (ii) clarify the effects of new payment formulae on individual grower's revenue, and (iii) increase transparency on value sharing between stakeholders.

Modelling structure and software

The software Pempa was developed with Microsoft Visual Basic.Net. This version does not require computer literacy and is available both in English and French. It is the subject of a data-processing patent filling and it is downloadable in free access on Internet on the website 'www.agri-logistique.cirad.fr'. Payment scenarios can be imported from, or exported to, an Excel file. This facilitates data input and offers users considerable time savings for configuration of the payment system.

The model is based on a three level representation of stakeholders: farms, groups of farms and mills. Stakeholders' links are represented through a pyramidal structure (Figure 1), including an elementary unit (EU), an EU group (Group) and the mill. An EU can be a farm, a part of a farm, a group of farms, etc. Each EU is characterised by their weekly deliveries and weekly quality indicators.

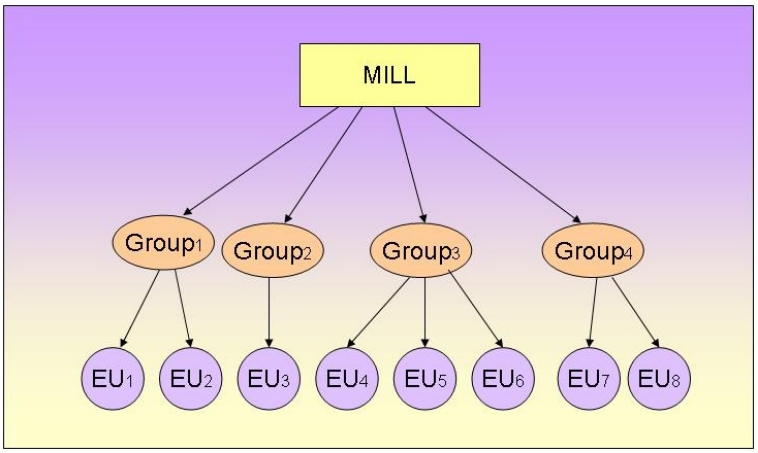

Fig. 1—Mill area structure.

Cane 'quality' is defined through a synthetic indicator (QI), which depends on elementary indicators, such as fibre, sucrose content, or data relative to the mill process. Four quality elementary indicators and a synthetic indicator (QI) can be defined to estimate EU 'quality'.

The payment model combines two sub-models: the first for quality parameters and the second for growers' income (Figure 2). Through the first sub-model, the synthetic indicator is defined, and average indicators are calculated for each grower, group of growers and the mill. The quality used for payment (QP) and the global payment formula can also be determined by users. Through the second sub-model, a stakeholder's revenue is calculated using tonnage and quality characteristics. Different sugar and co-product prices can be tested, such as different kinds of subsidies. Simulations are done on a weekly basis because the payment of growers is usually done using this time step.

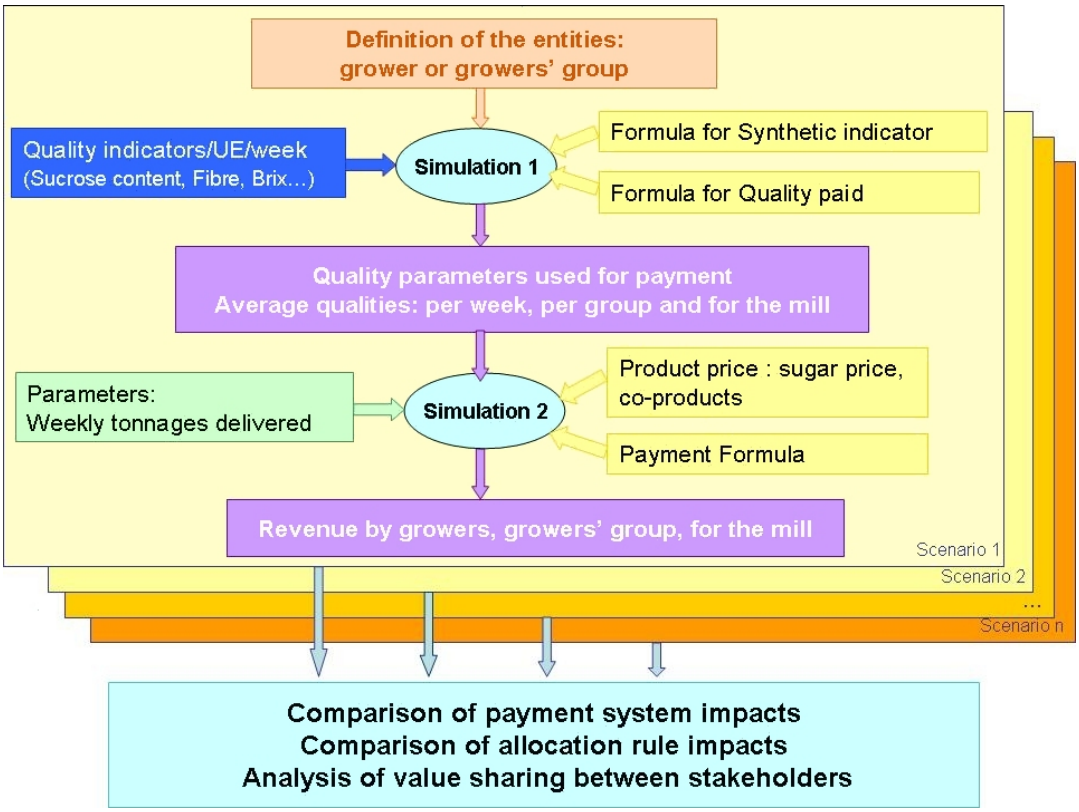

Fig. 2—PEMPA conceptual structure.

Simulations of different payment systems

Users may define a large panel of payment schemes depending on:

- The synthetic indicator (QI)

It can be modified using four elementary indicators, such as sucrose and fibre content. It can be an estimation of the sucrose content, the recoverable sugar present in each tonne of cane or the value of a tonne of cane in terms of marketable product. QI is chosen by the user and is a function of the elementary indicators (fibre, sucrose…). Various formulae for QI can be defined. This synthetic indicator can be defined on a weekly basis.

- The weekly paid quality

The formula to calculate paid weekly quality is designed by the users and could be based on the expression of the predefined synthetic indicator, but also the mill annual average quality, the group annual average quality, the weekly mill average quality and the group weekly average quality.

- The weekly payment formula

This synthetic indicator (QI) and the weekly paid quality (QP) can be used directly for payment or not. In a few countries, the quality paid is 'relative', i.e. representing the difference between the grower's weekly results and the mill average. The formula to calculate the weekly payment can be a function of the weekly paid quality and the synthetic indicator. The formula is calculated for each EU or for each group.

- The revenue formula

The parameters of the revenue formula (R) can integrate the three formulae before as members, but also the price of the sugar per tonne of cane, subsidies depending on tonnage or quality and the selling price of sugar or sugar by-products.

Simulation results

Pempa can be used to investigate the impacts of different payment schemes and quality incentives on growers' revenue, value sharing between growers and millers and value sharing among growers.

A wide range of issues may be addressed:

1. calculating growers' revenue for different payment formulae, at an individual level and/or for a whole group of farmers
2. assessing the impact of modifying the parameters used in a payment formula such as sugar price, qualitative parameters, new subsidies
3. testing the impact of delivery allocation modification on growers' income for a given payment formula
4. By comparing the results of the different scenarios, it is possible to calculate the value sharing between growers and miller and among growers. The results obtained can be analysed according to farm type or any other feature.

The tool calculates a stakeholder's revenue on a weekly and annual time step, according to given quality delivery characteristics and payment rules. The simulation results are represented at the three levels of the mill area structure: EU, PU, and mill.

Experiments conducted in Réunion

An experiment was carried out with two mills on Réunion Island. Two different payment systems have been tested: the current one and a payment system based on a relative formula.

Scenarios

In the current system, a synthetic indicator, called 'richesse', is used to estimate the amount of sugar that could be extracted from cane. It depends on the sucrose content (S), juice purity (p), bagasse (b) and fibre (f) rates (Figure 3).

Growers are paid according to their weekly results QI

$$QI = Rich = f(S, b, f, p)$$

As the 'richesse' (Rich) reaches a peak in the middle of the season, with this kind of payment, growers are understandably reluctant to deliver cane before or after this peak. Some growers tend to over-estimate their production at the beginning of the season, so as to have a higher weekly allocation and be able to deliver more cane in the middle of the season. Consequently, millers foresee a longer season length and do not work at their full crushing capacity at the beginning and end of the season. The extension of the milling season tends to reduce the season average sucrose content (Moor and Wynne, 2001) because the additional milling takes place at the beginning and end of the season, when the sucrose content is low.

Thus, we assessed the impact of switching from the current system to a relative one. The relative payment was designed to regulate deliveries when payment is done on a quality basis (Buchanan, 1974). In a relative payment system, growers are paid according to the difference between their quality and the weekly average of the mill. The $Richrel_{i,k}$ indicator used for payment is:

$$Richrel_{i,w} = (Rich_{i,w} - \overline{Rich_w}) + \overline{Rich}$$

Where $Rich_{i,w}$: Sugar content of grower i for week w

$\overline{Rich_w}$: Average sugar content for week w

$\overline{Rich}$: Mill average sugar content for the whole season

The impact of modifying the payment formula was simulated for the 3278 growers indexed in the Inter-professional Centre of the Cane and Sugar (CTICS) database. Simulations were performed for four different years using data for the seasons from 2001 to 2005.

Current system	**Scenario 'relative payment'**
Quality indicators In the current system, cane 'quality' depends on the sucrose content (S), juice purity (p), bagasse (b) and fibre (f) rates.	***Quality indicators*** Idem
Synthetic indicator A synthetic indicator, called 'sugar content', is used to estimate the amount of sugar that could be extracted from cane. It depends on the sucrose content (S), juice purity (p), bagasse (b) and fibre (f) rates. It includes specific coefficients depending on the measurement methods (E) and rates used as reference (fr: reference fibre rate; pr: juice purity rate). $QI = Rich = \frac{S*(1-b)}{E} + \frac{5(fr-f)}{100} + \frac{(p-pr)}{100}$	***Synthetic indicator*** Idem
Weekly quality paid $Rich_{i,w}$	***Weekly quality paid*** $Richrel_{i,w} = (Rich_{i,w} - \overline{Rich_{w}}) + \overline{Rich}$
Weekly payment $P_{w,i} = \frac{Po(Rich_{i,w} - 5.8)}{Rich_o - 5{,}8}$ With $Rich_o$: reference sugar content ; Po: Price of a tonne of sugarcane with sugar content Ro	***Weekly payment*** $P_{w,i} = \frac{Po(Richrel_{i,w} - 5.8)}{Rich_o - 5{,}8}$
Growers' revenue $R_i = \sum_{w=1}^{l} P_{w,i} * T_{w,i} + Subs\ 1 * Ttot + Subs\ 2$ With Subs1: subsidies depending on tonnage Subs 2: subsidies depending on EU	***Growers' revenue*** Idem

Fig. 3—From the current system to a relative payment.

Results

The analysis showed that switching from one payment to another (Figure 4):

- Did not modify the division of proceeds between millers and growers.
- Slightly modified large-scale growers' revenue.
- Could modify small-scale growers' income by around 20%**.**

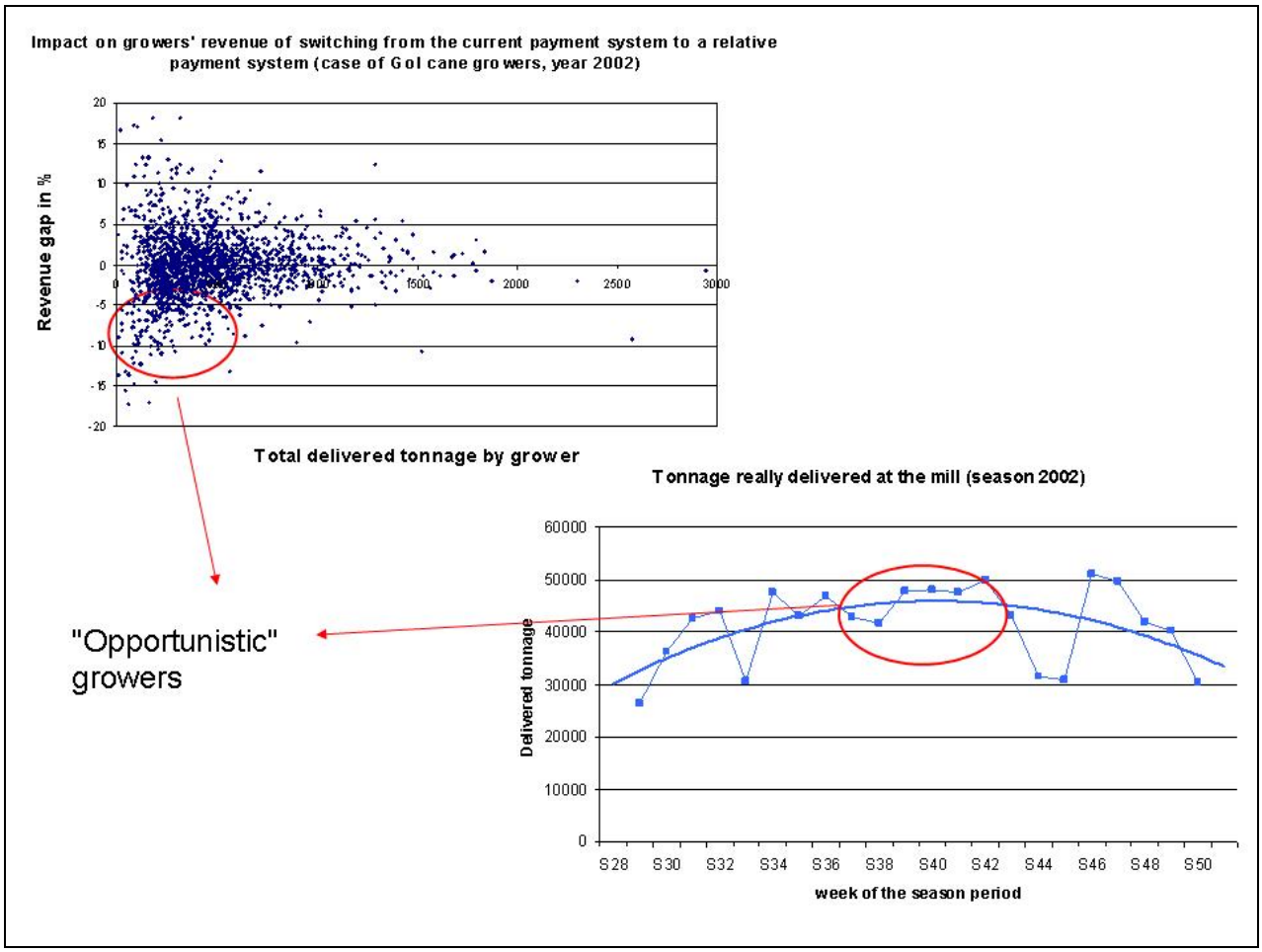

Fig. 4—Switching from one payment system to another.

We then identify and characterise the growers who were highly affected by the payment modifications.

We showed that:

- For most of them, losses were offset from one year to another. Only 8% of the growers lost part of their revenue every year.
- Growers who lost more than 10% of their income were those who systematically delivered more sugarcane at the middle of the season.

As expected, the simulations showed that the relative payment system would encourage growers to deliver cane regularly throughout the season. These results were discussed among stakeholders.

The discussion process highlighted the necessity to investigate a new scenario based on regular deliveries.

We thus simulated a modification in the tonnage delivered each week by these 10% of growers who systematically delivered more sugarcane at the middle of the season.

We showed (Figure 5) that, if they delivered regularly, milling capacity utilisation could be improved.

The season length could be reduced by one or two weeks. A reduction of two weeks could increase the total sugar production and total revenue by 4%, without any additional investment for millers or growers.

When the simulations were run on an inter-annual basis, we showed that a relative payment system and a season reduced by two weeks increased the revenue of all the growers (We supposed that logistics costs are not modified).

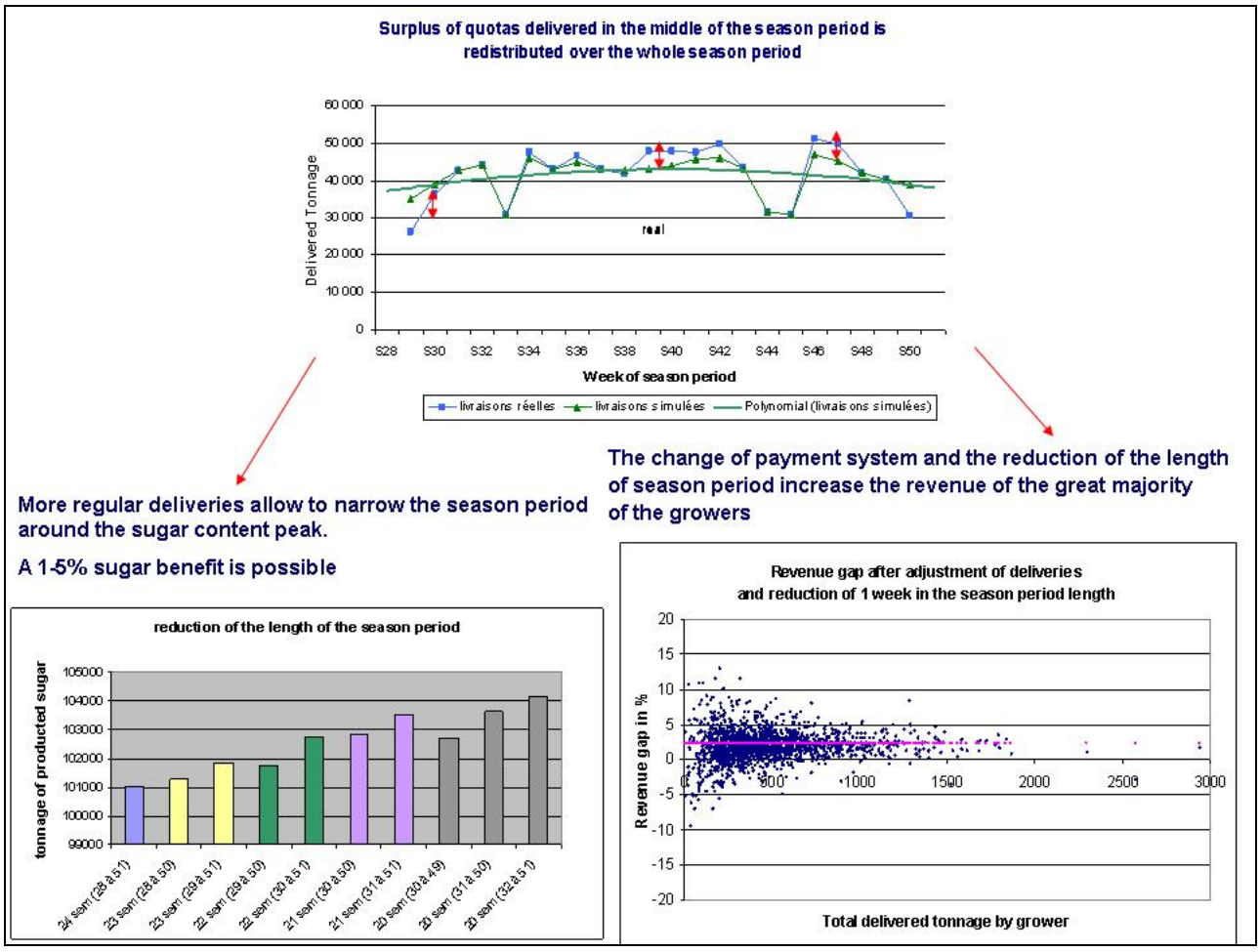

Fig. 5—Adjustment of deliveries and reduction in the length of the season period increase in the stakeholders' revenue.

Consequently, simulations showed that the relative payment system would encourage growers to deliver cane regularly throughout the season, resulting in improved utilisation of milling capacity and in a potential 2-week reduction in the season length.

Discussion

Pempa should be used in collaboration with stakeholders involved in sugarcane payment system elaboration and outsiders such as researchers or consultants.

Scenarios should be designed with a steering committee that at least includes growers' and millers' representatives, as this sort of issue requires participation and agreement of every stakeholder's group.

Once stakeholders have agreed on the payment system to be studied or modified, scenarios are configured and can be simulated using the software. The scenario outputs are compared mainly on the basis of individual revenue and value sharing.

The simulation tool promotes discussion between grower and miller representatives on potential changes in payment systems**.** It provides information that enhances and facilitates the negotiation process between stakeholders.

The purpose of the tool was to better formalise payment systems and value sharing among stakeholders. The simulations and the stakeholders' participation provided greater insight into both the nature of relative cane payment and opportunities for improving industry efficiency by adopting such a system.

Conclusion and prospects

The division of proceeds between growers and processors may lead to conflicts between the two groups. Modelling and simulation could considerably increase transparency and facilitate the implementation of new payment schemes, with the support of professionals and researchers, providing a quick and reliable way for assessing and comparing alternative scenarios.

Pempa makes it possible to evaluate new payment formulae, designed and developed in partnership with sugar industry stakeholders. This tool enables their evaluation and facilitates their comprehension while clarifying their individual effects.

Pempa could be used to support implementation of new payment scheme designed for multiple purpose cane (sugar, electricity, ethanol, etc.). At this stage, we do not have an example of a quality-based payment system for multi-purpose sugarcane. However, once a formula or a set of potential formulae are designed, PEMPA could be used to support implementation of a new payment scheme designed for multi-purpose sugarcane.

Profits and their distribution between the stakeholders can be calculated for each use. However, this step must be accompanied by an analysis of parameters that should be considered to evaluate the 'quality' of cane for products other than sugar.

Moreover, this tool could be further extended by including other parties involved in production and processing within the supply chain, particularly hauliers and independent workers, who are paid on a tonnage basis whereas their work has an impact on the product quality. The current software is designed to include these other parties, which could be paid through a different payment formula.

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UNE APPROCHE D'AIDE A LA DECISION POUR METTRE EN OEUVRE DES NOUVEAUX SYSTEMES DE PAIEMENT BASE SUR LA QUALITE DANS LA CANNE A SUCRE

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MOTS CLÉS: Incitation, Qualité, Sous Produits, Approche Participative, Canne à Sucre, Méthode de Paiement.

Résumé

DANS LES industries sucrières où les planteurs et les usiniers sont des entités économiques indépendantes, les systèmes de paiement visent à partager les revenus annuels de ces industries. Ils ont été conçus pour créer des incitations afin d'améliorer les performances d'usinage, les rendements et la qualité des cannes. Comme la plupart des accords pour le partage des revenus, ces systèmes causent parfois des litiges entre planteurs et usiniers. Dans certains secteurs, le changement des systèmes de paiement peut être la clé pour accroître la rentabilité de l'industrie mais la méfiance entre planteurs et usiniers peut entraver ces améliorations. La situation s'est aggravée aujourd'hui avec le développement des coproduits de la canne à sucre, comme l'éthanol, l'électricité ou les sous-produits pour des marchés ciblés, qui peuvent générer des bénéfices plus élevés que le sucre, ce qui amène à revoir les systèmes de paiement. Les auteurs présentent une approche d'aide à la décision pour évaluer les nouveaux systèmes de paiement de canne à sucre avec plus de transparence dans le partage des revenus. Il est basé sur un outil de simulation appelé Pempa, qui aide à évaluer l'impact des nouveaux systèmes de paiement de canne sur les revenus des planteurs et du partage des revenus entre les parties concernées. Des expériences ont été effectués à la Réunion pour les 3200 planteurs fournissant des cannes à deux usines pour tester l'effet de la mise en œuvre d'un nouveau système de paiement basé sur une formule relative. Les résultats ont démontré que l'approche de simulation pourrait faciliter la compréhension et la mise en œuvre d'une nouvelle formule de paiement, en particulier pour les multiples produits de la canne.

UN ENFOQUE DE SOPORTE DE DECISIONES PARA TRATAR SISTEMAS DE PAGO BASADOS EN CALIDAD

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PALABRAS CLAVE: Incentivo de Calidad, Co-Productos, Estrategia de Participación, Caña de Azúcar, Esquema de Pago.

Resumen

EN LAS industrias azucareras donde los productores de azúcar y los productores de caña son entidades económicas independientes, los sistemas de pago están encaminados a compartir el retorno anual de la industria. Estas se han diseñado para crear incentivos para mejorar el desempeño de la molienda, la productividad en campo y la calidad. Tal como sucede en la mayoría de convenios donde se comparten ganancias, se crea rivalidad entre los productores y los ingenios. En algunas industrias, mientras la modificación de los sistemas de pago ha sido la clave para mejorar la rentabilidad de la industria, la desconfianza entre los productores y los ingenios puede ensombrecer las mejoras. La situación está ahora agravada por el desarrollo de co-productos de azúcar, como el etanol y la electricidad o los otros productos para nichos de mercado específicos, que pueden generar beneficios más altos que los del azúcar, lo que llama a replantear los sistemas de pago.Este trabajo presenta una estrategia para la toma de decisiones que promueve la búsqueda de nuevos sistemas de pago mientras se incrementa la transparencia en la distribución de ganancias. Está basada en una herramienta de simulación llamada Pempa, que ayuda a evaluar el impacto de nuevos sistemas de pago en las ganancias de los productores y en la distribución de retornos entre las partes interesadas. Se llevaron a cabo experimentos para 3200 productores de caña que proveen materia prima a dos ingenios de la Isla Reunión, para evaluar el impacto de la implementación de un nuevo sistema de pago basado en una fórmula relativa. Los resultados mostraron que la estrategia de simulación podía facilitar el entendimiento y la implementación de una nueva fórmula de pago, especialmente cuando la materia prima se usa para diferentes propósitos.